

## STORMS AND WARNINGS—WEATHER AND CROPS.

## STORMS AND WEATHER WARNINGS.

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[Washington, May 4, 1920.]

The month of March was characterized by persistent and marked storm activity, and there were very few days, indeed, without some considerable portion of the country under the influence of severe weather conditions.

There were four major storms that moved across the United States, and two others that were only a little less pronounced. The four major storms were attended by widespread rains and snows, gales, and by subsequent low temperatures. A somewhat detailed description of each will be given.

*Storm of March 1-7.*—This storm was first noted on the morning of March 1 off the central California coast, marked high pressure prevailing at the time over Alaska. During the succeeding 48 hours the low developed rather slowly to the eastward, while the Alaska high moved across the United States and Canadian Northwest, both with steadily increasing intensity, so that on the morning of March 3 the storm center was over southwest Kansas (Dodge City, 29.48 inches), and the crest of the high over northern Saskatchewan (Battleford, 30.60 inches). East of the Mississippi River pressure was also high, decidedly so over the Northeast. At this time the first warnings were issued in the Washington district, namely, small-craft warnings for the middle gulf coast for fresh, possibly strong southeast winds, and advisory warnings for open ports on Lake Michigan for fresh, possibly strong, east to north winds with snow.

On the evening of March 3 the storm center was over the upper Mississippi Valley, with abnormally high pressure and rapidly falling temperature to the northwestward, and at 10:30 p. m. SE. storm warnings were ordered along the middle Gulf coast. On the morning of March 4 the region of greatest storm activity extended in a narrow trough from Louisiana to Lake Michigan, with three distinct centers, one over southern Mississippi, one over central Illinois, and a third over southern Lake Michigan, pressure continuing to rise over the Northwest with very low temperatures. The advisory warnings for Lake Michigan were repeated in more emphatic form, gales, snow, and much colder weather being forecast, and the forecasts for nearly all sections east of the Mississippi River carried warnings of strong winds. At 11:30 a. m. NW. storm warnings were ordered displayed generally along the Gulf coast from Bay St. Louis, Miss., to Carrabelle, Fla., strong north winds with clearing and much colder weather being forecast. Cold-wave warnings were also ordered for the upper Lake Region, west Tennessee, and the East Gulf States, and warnings of frost for southern Florida and of freezing temperatures for the remaining southern districts.

Special 1 p. m. observations showed a slow eastward movement of the storm, and at 4 p. m. SE. storm warnings were ordered displayed along the Atlantic coast from Eastport, Me., to Jacksonville, Fla., winds to become strong from S. and to shift to NW. by the night of the 5th. NW. warnings had also been ordered on the East Gulf coast from Cedar Keys to Tampa, Fla.

After the morning of the 4th the storm moved more rapidly, and on the following morning it extended from the Carolina coast to eastern Ontario with the principal center over the southern section. The SE. warnings were changed to NW. from Jacksonville, Fla., to Ports-

mouth, N. H., and those at Cedar Keys and Tampa, Fla., lowered. At 3 p. m. of this day (5th), the following advisory warning was sent to stations and others interested:

Pressure continues to fall rapidly at coast stations. Center of disturbance near Cape Henry, apparently moving northeast. Will cause severe gales, becoming north and northwest over steamer lanes for the next 36 hours. Much colder.

Cold-wave warnings were also ordered on the morning of the 5th for the Atlantic States and western New York, and frosts forecast as far south as the southern limits of the Florida mainland. In the evening the warnings on the south Atlantic coast were lowered, and on the morning of the 6th, with but a single storm center off the southern New England coast (Block Island, R. I., 28.82 inches), the NW. warnings were continued from Delaware Breakwater northward. Severe gales were in progress at the time (Block Island, 60 mi./hr.), and heavy snows had been falling over the Middle Atlantic States, continuing over New York and southern New England. Cold-wave warnings were ordered for Maine and eastern New York, and warnings of heavy frost, or freezing temperatures, throughout the South. At 8 p. m. of the 6th the barometer read 28.72 inches at Eastport, Me., with gales continuing from New York City northeastward, New York reporting a maximum velocity of 72 mi./hr. from the NW. On the morning of the 7th the storm center was beyond New Brunswick, the gales had subsided, and high pressure and low temperatures prevailed throughout the entire country east of the Rocky Mountains, except over the Northeast. The last warnings in connection with this storm were then issued, forecasting another night of freezing temperatures and heavy frosts throughout the South.

All warnings issued during this storm were fully justified by the subsequent occurrences, and marine disasters were remarkably few.

*Storm of March 9-15.*—The second great storm apparently originated during March 8 over Nevada, and by the following morning a moderate low had formed. For two days it moved slowly eastward with increasing intensity, and on the morning of the 11th it was central over NW. Kansas (Goodland, 29.48 inches). Pressure was then quite high over the Atlantic States and the north Atlantic Ocean (Bermuda, 30.52 inches), and at 11 a. m. SE. storm warnings were ordered along the Gulf coast from Carrabelle to Pensacola, Fla., and small-craft warnings over the Mobile, Ala., district. After the morning of the 11th, the low moved more rapidly, and reached central Illinois by evening with rapidly rising pressure to the westward and northwestward. Advisory warnings were then sent to open ports on Lake Michigan for moderately strong NW. winds during the next day with lower temperatures and rain turning to snow. The storm path now turned sharply to northeast with the usual increase in intensity attending such movement, and on the morning of March 12 the storm was central over Georgian Bay (Alpena, Mich., 29.22 inches), with strong NW. and N. winds and snow on Lakes Superior and Michigan.

A slight secondary disturbance had also appeared over NE. Texas on the evening of the 11th, and began to move eastward, and a tornado occurred in southwest

Missouri (see p. 158, above). At 11 a. m. SW. storm warnings were ordered along the Atlantic coast from Eastport, Me., to Hatteras, N. C., for strong S. and SW. winds, shifting to NW. on Saturday, March 13. By 8 p. m., March 13, the primary storm center had passed beyond Newfoundland, while the secondary one, which had reached the southern Appalachian region on the previous evening, had also made a turn to the northeastward, and was over New Jersey with a marked increase in energy (Philadelphia, Pa., Atlantic City, N. J., and New York City, 29.34 inches). General rains were falling but there had not yet been any strong winds north of Hatteras. At 11 a. m. NW. storm warnings were ordered south of Hatteras as far as Jacksonville, to be lowered at sunset, and the SW. warnings to northward changed to NW., winds of gale force being forecast. Cold-wave warnings were also ordered for portions of interior New England and the Middle Atlantic States, and frost warnings to southward as far as extreme northern Florida. At 8 p. m. March 13 the storm center was near the western Maine coast (Portland, Me., 28.90, and Boston, 28.92 inches), and by the following evening it had reached Newfoundland. On the morning of March 14 the NW. storm warnings were ordered continued from Point Judith, R. I., to Eastport, Me., and by the morning of the 15th the gales had subsided.

All storm warnings ordered for this storm were fully verified, but the cold-wave warnings were only partially verified, although there was a decided fall in temperature.

*Storm of March 13-17.*—The third great storm. Pressure had remained much below the normal over the Aleutian Islands since March 4, and on the morning of the 13th another offshoot from the general depression was central over the north coast of Washington. It moved southeastward at a fair rate of speed, but with rapidly increasing development, and by the evening of March 14 it had reached western Nebraska (North Platte, 28.90 inches), the general depression covering the entire interior district from the Mississippi Valley westward. At 9:30 p. m. advisory warnings were sent to open ports on Lake Michigan for moderately strong winds on the following day, and at 11 p. m. SE. storm warnings were ordered along the Gulf coast from Bay St. Louis, Miss., to Carrabelle, Fla., for strong S. winds during the next 36 hours. During the night of the 14th-15th the storm track turned abruptly to the north-northeastward, and on the morning of the 15th it was over eastern South Dakota (Moorhead, Minn., 28.68 inches). Advisory warnings were repeated to open ports on Lake Michigan, and included therein were forecasts of strong NW. winds on the following day with rain and snow and falling temperatures. At noon of the 15th SW. storm warnings were ordered along the Atlantic coast from Provincetown, Mass., to the Virginia Capes, strong SE. and SW. winds being forecast. At 8 p. m. the barometer at Moorhead, Minn., read 28.56 inches, and on the following morning the storm center was northwest of Lake Superior (Duluth, Minn., and Port Arthur, Ontario, 28.94 inches). Advisory warnings were again sent to open ports on Lake Michigan, and the SW. warnings continued on the Atlantic coast. At 4 p. m. the SW. warnings were extended northward to Eastport, Me. The storm center continued its northeastward course with increasing velocity of progression, passing south of and near James Bay, and on the morning of the 16th it was over New Brunswick. By evening it had passed beyond St. John's, F.

All warnings issued in connection with this storm were verified.

*Storm of March 26-30.*—Fourth great storm. This storm was a secondary development of a primary LOW to the northward, and was first noted over southwestern Utah on the morning of March 26. It moved almost due eastward during the first 36 hours, and at 8 p. m., March 27, it was central over western Kansas (Dodge City, 29.16 inches). Advisory warnings for strong SE. winds were at once sent to open ports on Lake Michigan, and repeated on the following morning, a shift of the strong winds to NW. with rain or snow and lower temperatures being forecast. The storm center by this time had turned to north-northeastward with steadily increasing intensity, and was over extreme eastern Nebraska (Sioux City, Iowa, 28.96 inches), with a great depression covering the entire center of the country. After the receipt of special noon observations, SW. storm warnings were ordered along the Atlantic coast from Eastport, Me., to Charleston, S. C., strong winds shifting to SW. being forecast. The storm was then central over southern Minnesota (Minneapolis, 28.96 inches), and strong shifting gales had occurred to the southward and southwestward. It was only a few hours after this time that the disastrous tornadoes occurred over portions of Illinois, Indiana, Ohio, Michigan, Alabama, and Georgia, causing the loss of 88 human lives, and property destruction to the amount of about \$10,000,000. Detailed reports of these tornadoes will be found in the April issue of this REVIEW.

At 8 p. m., March 28, the storm center was over northern Wisconsin (Green Bay, Wis., and Duluth, Minn., 28.98 inches), and by the following morning it was north of and near Lake Superior (White River, Ontario, 28.88 inches), with a more rapid northeastwardly movement. A more moderate secondary LOW appeared during the night preceding over West Virginia, and by 8 p. m., March 29, it was off the north coast of Massachusetts with much increased energy. The warnings from New York City to Eastport, Me., were then changed to NW., while those to the southward were allowed to expire.

On the morning of the 30th, the LOW center was over the Gulf of St. Lawrence, with still lower pressure (Father Point, Quebec, 29.30 inches), and by evening it was over Newfoundland.

All warnings issued for this storm were justified by subsequent occurrences, except in a few localities.

*Storm of March 15-21.*—This storm, while also characterized by abnormally low pressures, did not cause any strong winds of consequence over the district, except along the northern New England coast, and its failure in this respect was doubtless due to the absence of high pressure and low temperatures immediately preceding or following. The storm came from the north Pacific Ocean, and was definitely charted on the evening of March 15 over southwest Oregon (Roseburg, 29.40 inches). The great storm that had immediately preceded was then over northwest Minnesota. The Oregon LOW moved southeastward to southern Utah, thence east-northeastward by way of northwest Kansas, reaching northwest Iowa on the evening of March 18 (Sioux City, 29.30 inches).

The usual advisory warnings were then sent to open ports on Lake Michigan. After this time the storm center moved more directly eastward, and at 1 p. m., March 19, was over northeast Ohio (Erie, Pa., 29.36 inches). At 3:30 p. m. SE. storm warnings were ordered along the Atlantic coast from Portland, Me., to Delaware Breakwater, Del., and SW. warnings to southward as far as Hatteras, N. C. By evening the storm had divided into two distinct sections, one over western New York and the other over southwestern Virginia, with a slight

secondary over eastern Maryland. Both the main sections moved rapidly northeastward during the night, and on the morning of the 20th, the Virginia one was over the Island of Nantucket (29.18 inches). By evening it had passed over Newfoundland, and in the meantime the northern section had disappeared.

As stated above, no strong winds occurred, except along the Maine coast. There were, however, some very heavy snows over portions of New York and New England.

*Storm of March 24-27.*—On the morning of March 24 a well-defined low extended in the form of a narrow trough from eastern New Mexico to southern Minnesota, with a center of disturbance at each end, the northern one disappearing to the northward of Lake Superior during the succeeding night. On the morning of March 25 the southern low was central over Oklahoma (Altus, 29.14 inches), and SE. storm warnings had been ordered on the previous evening along the Gulf coast from Bay St. Louis, Miss., to Cedar Keys, Fla. Orders were issued at 3 p. m., March 25, to change these warnings to SW. at sunset, and SW. warnings were also ordered on the Atlantic coast from Jacksonville, Fla., to Charleston, S. C. At 8 p. m. the center of the storm was over SE. Iowa (Keokuk, 29.02 inches), and advisory warnings for strong winds and rain were sent to open ports on Lake Michigan. By the evening of March 26 the storm center was northeast of Lake Superior, and on the morning of March 28, it was north of Newfoundland with undiminished intensity.

The warnings issued on the 24th and 25th for the Gulf coast and the Jacksonville-Charleston section of the Atlantic coast were verified, except on the Atlantic coast, where only fresh winds occurred.

Still another severe storm appeared during the 29th north of British Columbia and developed to the southeastward. This storm will be discussed in the MONTHLY WEATHER REVIEW for April, 1920. The SE. storm warnings ordered at 3 p. m., March 25, on the New England coast were ordered as a matter of precaution, as a disturbance was moving northward over the western Atlantic Ocean, only a short distance from the coast, and its intensity was problematical. No strong winds followed, and the warnings were unnecessary.

#### WARNINGS FROM OTHER DISTRICTS.

*Chicago, Ill., forecast district.*—The month was marked by the movement in rapid succession of a remarkable series of low-pressure areas across this forecast district. The barometer was abnormally low in most of the storm areas. As the disturbances advanced they were attended by general rains and high winds and even gales.

The storm which crossed the district during the 3d and 4th was the only one that was followed by a well-marked cold wave, the highs not following the lows in the usual order with marked changes in temperature.

The disturbance which advanced eastward across the Rockies on the 2d and reached Kansas on the 3d was one rather of the winter type, and by the evening of the 4th it had crossed the Upper Lake Region. Snow was general on its northern and western sides, with strong winds and falling temperature. Warnings to live-stock interests were issued on the morning of March 2 to South Dakota, Nebraska, and Wyoming points. Additional warnings were sent to Nebraska on the morning of the 3d and to Kansas and west Missouri. The messages

contained advices of snow, cold weather, and strong northwest winds. Cold-wave warnings were also issued on the 3d to the Central Plains States, and they were extended on the morning of the 4th to Illinois and a portion of Wisconsin. These warnings, as well as the advices to stock interests, were fully verified, and it is believed that transportation and stock were protected from the severe conditions which followed. The cold was persistent for several days following the passage of this storm, temperatures being particularly low in the Northwest. A reading of  $-32^{\circ}$  was reported at Billings, Mont.

Beginning on the 10th, the weather conditions became especially active. The storm which passed across the district on the 10th and 11th covered a wide area, but the barometer readings were not especially low. However, a few days later, in the storm which crossed over the more northerly States on the 14th to 16th, the pressure was very low, 28.56 inches being reported at Moorhead, Minn.

While the pressure in the following two storms was also low, it was not until the 28th that the reading again fell below 29 inches. On the morning of that day the barometer at Sioux City, Iowa, registered 28.96 inches. In the southeast quadrant of this storm, far from the center, in northern Illinois, three distinct tornadoes developed, which caused damage amounting to \$3,150,000, 225 houses were wrecked, and 28 lives were lost, and 300 injured.

There were seven storms in all which crossed the district, and each one was attended by more or less severe gales. Generally speaking, it was probably the windiest month in this forecast district for a long period of years. Warnings of the gales were given in advance of these storms to the vessel interests on Lake Michigan maintaining winter navigation.

Warnings of snow and colder, with strong northwest winds, were sent to the live-stock interests on the morning of the 11th to points in Kansas and west Missouri, and on the morning of the 17th to Wyoming and west Nebraska. The conditions following these warnings were not as severe as those of the storm during the early days of the month, but nevertheless the warnings were justified.—H. J. Coz.

*New Orleans Forecast District.*—Storm or small craft warnings were issued for the Texas coast on the 3d, 11th, 14th, 24th, and 27th, and for the Louisiana coast on the 4th and 24th. These warnings were generally justified. No general storm occurred without warnings.

A cold wave overspread the district during the 3d, 4th, and 5th, for which timely warnings were issued. No cold wave of any importance occurred without warning.

Five weather warnings were issued as occasion required.—I. M. Cline.

*Denver Forecast District.*—The month was characterized in the Denver Forecast District by abnormally low temperature and windy weather. An unusually large number of deep storms from the Pacific coast crossed the district, causing frequent serious delays in telegraphic service and some interruption to railroad traffic in the mountain districts. Some winter grains were uncovered in eastern Colorado by strong winds. As is usual in storms that cross the mountains, an excess of precipitation occurred on the western slope and a deficiency in the districts east of the mountains. Record-breaking cold weather prevailed in eastern Colorado in the fore part of the month, an anticyclone of marked intensity spreading